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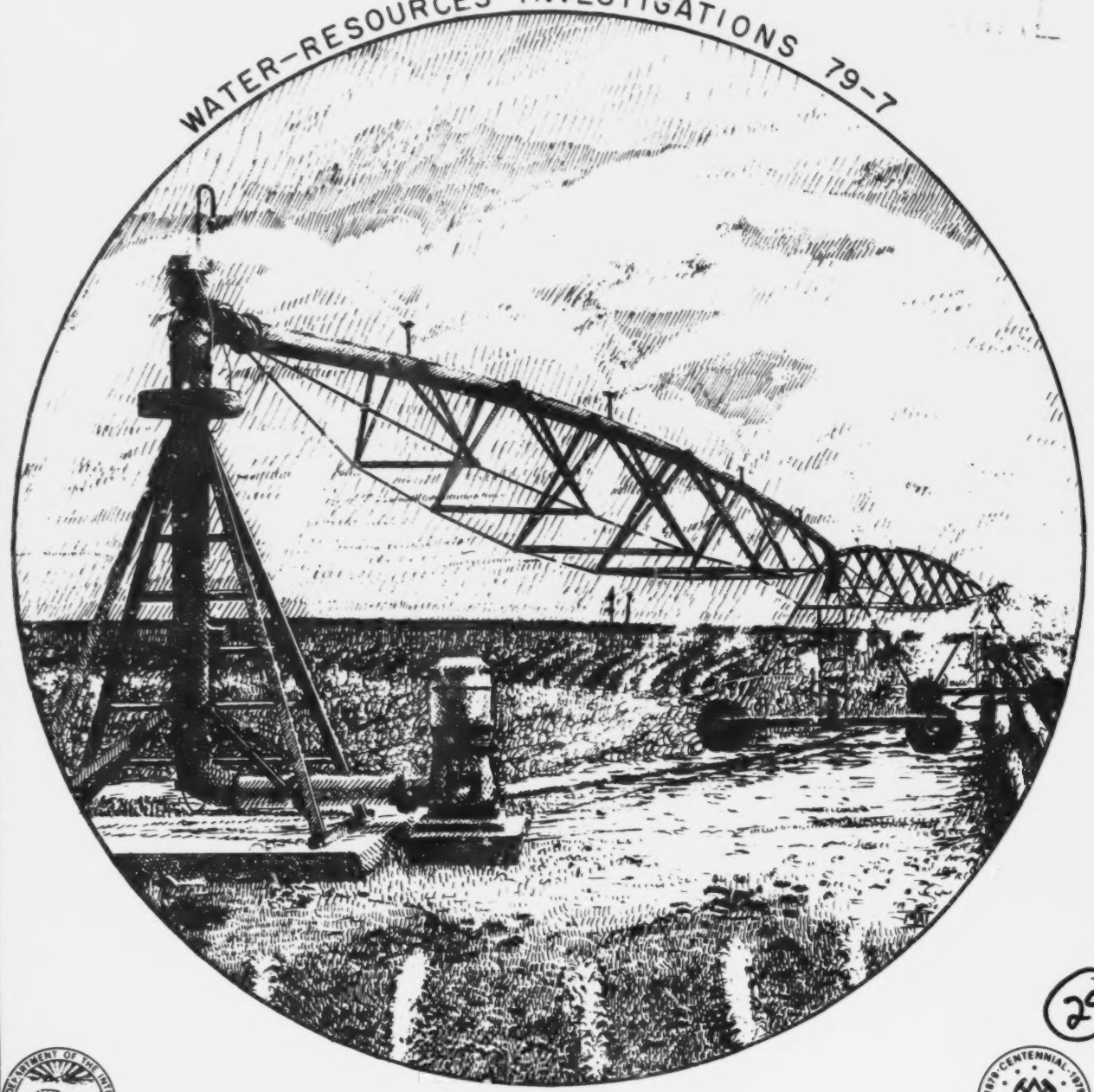
PRELIMINARY APPRAISAL OF THE IMPACT OF AGRICULTURE ON GROUND-WATER AVAILABILITY AND QUALITY IN SOUTHWEST GEORGIA

COMPLETED

U.S. GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS 79-7



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Prepared in cooperation with the
Georgia Department of Natural Resources

A PRELIMINARY APPRAISAL OF THE IMPACT OF AGRICULTURE ON GROUND-WATER AVAILABILITY IN SOUTHWEST GEORGIA

By L. D. Pollard, R. G. Grantham, and H. E. Blanchard, Jr.

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the Georgia Department of Natural Resources

October 1978

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONTENTS

	Page
Abstract	1
Introduction	1
Geographic setting	2
Previous studies	4
Geohydrologic background	5
Geology	5
Hydrology	6
Ground-water use	10
Ground-water quality	16
Summary and conclusions	20
Selected references	21

ILLUSTRATIONS

Page

[Plates are in pocket]

Plate 1. Geology of south Georgia showing the recharge area and areal extent of the principal artesian aquifer.

2. Map showing the potentiometric surface of the principal artesian aquifer, Dougherty Plain district, November-December 1977, southwest Georgia.

3. Map showing the potentiometric surface of the principal artesian aquifer, Dougherty Plain district, March 1978, southwest Georgia.

4. Map showing location of irrigation, observation, and water-quality wells and district divisions of Coastal Plain province, southwest Georgia.

Figure 1.	Map showing location of study area and counties described in previous hydrologic reports	3
2.	Map showing physiographic districts in study area	4
3.	Generalized geologic section showing the relation of the principal artesian aquifer to overlying and underlying deposits	5
4.	Hydrograph showing water levels in observation well 6, Albany, Dougherty County, and the cumulative departure of precipitation, 1963-77	6

ILLUSTRATIONS---Continued

Page

Figure 5. Hydrograph showing long-term water-level conditions, 1963-77, compared to the mean water levels for observation well 6, Albany, Dougherty County, 1977..... 7

6. Hydrograph showing water levels in observation well 2, Decatur County, June 1969-April 1978..... 7

7. Hydrograph showing water levels in observation well 2, Decatur County, January 1977-April 1978..... 8

8. Hydrograph showing the seasonal response of water levels to pumping in observation well 3, Miller County, February 1977-April 1978..... 9

9. Map showing percentage distribution of irrigation water use by source, 1977..... 14

10. Map showing estimated ground-water use, 1977..... 15

11. Map showing the areal distribution of a theoretical water-level decline after 5 days of pumping 133 irrigation wells in Decatur County..... 17

TABLES

Page

Table 1. Summary of irrigation data in the 20-county study area in southwest Georgia..... 11

2. Summary of irrigation inventory by county..... 12

3. Concentration of selected constituents from ground water.... 18

FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

Multiply inch-pound units	By	To obtain SI units
Foot (ft)	0.3048	meter (m)
Gallon per minute (gal/min)	0.06309	liter per second (L/s)
Million gallon per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	28.32	liter per second (L/s)
	Specific capacity	
Gallon per minute per foot of drawdown [(gal/min)/ft]	0.207	liter per second per meter [(L/s)/m]
	Transmissivity	
Foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)

A PRELIMINARY APPRAISAL OF THE IMPACT OF AGRICULTURE ON GROUND-WATER AVAILABILITY AND QUALITY IN SOUTHWEST GEORGIA

By L. D. Pollard, R. G. Grantham, and H. E. Blanchard, Jr.

ABSTRACT

Irrigated acreage in the study area in southwest Georgia increased from 130,000 acres in 1976 to 261,000 in 1977. Acreage irrigated entirely by ground water increased 85 percent for the same period. The largest quantity of ground water used for irrigation was in the Dougherty Plain district, where 92 percent of supplemental irrigation water comes from wells. In the Tifton Upland district, ground water is the source for only 16 percent of the irrigation water used. The major ground-water reservoir supplying the irrigation water is the principal artesian aquifer.

The Dougherty Plain, because of the gently rolling land surface and large fields, is suitable for the use of large self-propelled center-pivot irrigation systems requiring 1,200 to 1,500 gallons per minute. The installed pump capacity of the irrigation systems in the Dougherty Plain using ground water was 1.8 billion gallons per day in 1977. The total amount of water pumped for irrigation in the Dougherty Plain in 1977 was more than 42 billion gallons, 30 billion gallons more than in 1976. This quantity could be considerably higher in 1978 as preparations were being made to irrigate more than 214,000 acres during the 1978 growing season.

There were no concentrations of selected organic compounds or trace metals used in agricultural chemicals above the recommended limits for public consumption in water analyzed from 19 wells. However, concentrations of total nitrite plus nitrate ranged from 0.3 to 7.8 milligrams per liter in wells in the Dougherty Plain, and this could indicate that the downward percolation of water through sandy soils has carried soluble nitrate, a byproduct of fertilizer, into the ground-water reservoir.

INTRODUCTION

A 20-county area in southwest Georgia was selected for the purpose of studying the impact of agriculture on ground-water availability and quality. This area showed rapid growth in the amount of irrigated acreage during the past 10 years. This increase was indicated in the "1969 Census of Agriculture" and the "1974 Census of Agriculture Preliminary Report," published by the U.S. Department of Commerce, Bureau of the Census, and in surveys conducted by Robert E. Skinner, Extension Engineer, Cooperative Extension Service, University of Georgia. Irrigated acreage in southwest Georgia increased 60 percent from 1970 to 1971 and increased approximately 100 percent from 1976 through the fall of 1977. Acreage irrigated entirely by ground water increased 85 percent from 1976 through the fall of 1977.

Large-acreage self-propelled irrigation systems have increased crop production and, at the same time, have rapidly increased the withdrawal of ground water. Because of the large number of irrigation systems being installed and the practice of multicropping, the agricultural impact on the ground-water reservoirs is being studied.

The U.S. Geological Survey, in cooperation with the Georgia Department of Natural Resources, Environmental Protection Division, collected the preliminary agricultural water-quality and water-use data. The U.S. Geological Survey later contracted with the U.S. Soil Conservation Service to collect water-use data in each of the 20 counties in the study area. The following information was collected: the quantity of water used for irrigation, the source of irrigation water, the number and type of irrigation systems being used, the reported capacity in gallons per minute of both the well and the irrigation system, the number of acres irrigated in 1976 and 1977, and the number of additional acres to be irrigated in 1978.

Water was collected from 19 wells throughout the study area. These samples were analyzed for the presence of agriculturally related chemicals.

Geographic Setting

The study area is in the southwest corner of Georgia in the Coastal Plain physiographic province (fig. 1). The area includes 20 counties composing the Dougherty Plain district, most of the Tifton Upland district, and small parts of the Fall Line Hills, the Vidalia Upland, and the Bacon Terraces districts of the Coastal Plain province (fig. 2).

The Dougherty Plain district is the most important area in terms of total irrigated acreage and quantity of ground water being used for irrigation. The land is flat to gently rolling, has few streams and, therefore, is adaptable to large pivot-irrigation systems. This district is underlain by carbonate rocks, primarily limestone. The limestone is conducive to ground-water movement because it contains networks of solution cavities. These cavities range in size from very small (less than 0.01 in.) to large, such as a sinkhole covering an acre or more of land. Sinkholes form the karst surface of the Dougherty Plain.

The next most important district is the Tifton Upland, a rolling upland having numerous surface streams and an absence of sinkholes and other solution features. Because the rolling topography and field size limit the use of large pivot-irrigation systems, smaller systems such as cable tows are numerous.

The northwest edge of the study area is in the Fall Line Hills district. This district is highly dissected by streams and has little level land. The boundary between the Fall Line Hills and the Dougherty Plain districts approximates the 250-foot contour line on topographic maps (Clark and Zisa, 1976). The boundary between the Fall Line Hills and the Tifton Upland districts follows the northern extremity of the Pelham Escarpment.

Ben Hill is the only county in the study area in the Vidalia Upland district. The southwestern boundary of this district is the continuation of the Pelham Escarpment. This district is moderately dissected by streams that exhibit a well-developed dendritic pattern.

The southeastern part of Ben Hill and the eastern part of Irwin Counties are in the Bacon Terraces district. This district consists of moderately dissected terraces, which generally parallel the Atlantic coastline.

REPORT	COUNTY
Krause (1979)	Brooks
Owen (1963b)	Mitchell
Owen (1958, 1963a)	Lee
Vorhis (1972)	Crisp and Lee
Wait (1963)	Dougherty
Watson (1976)	Ben Hill, Turner, Tift, Irwin, and Worth
Sever (1965)	Seminole, Decatur, and Grady
Sever (1966)	Thomas
Sever (1972)	Cook
Zimmerman (1977)	Colquitt

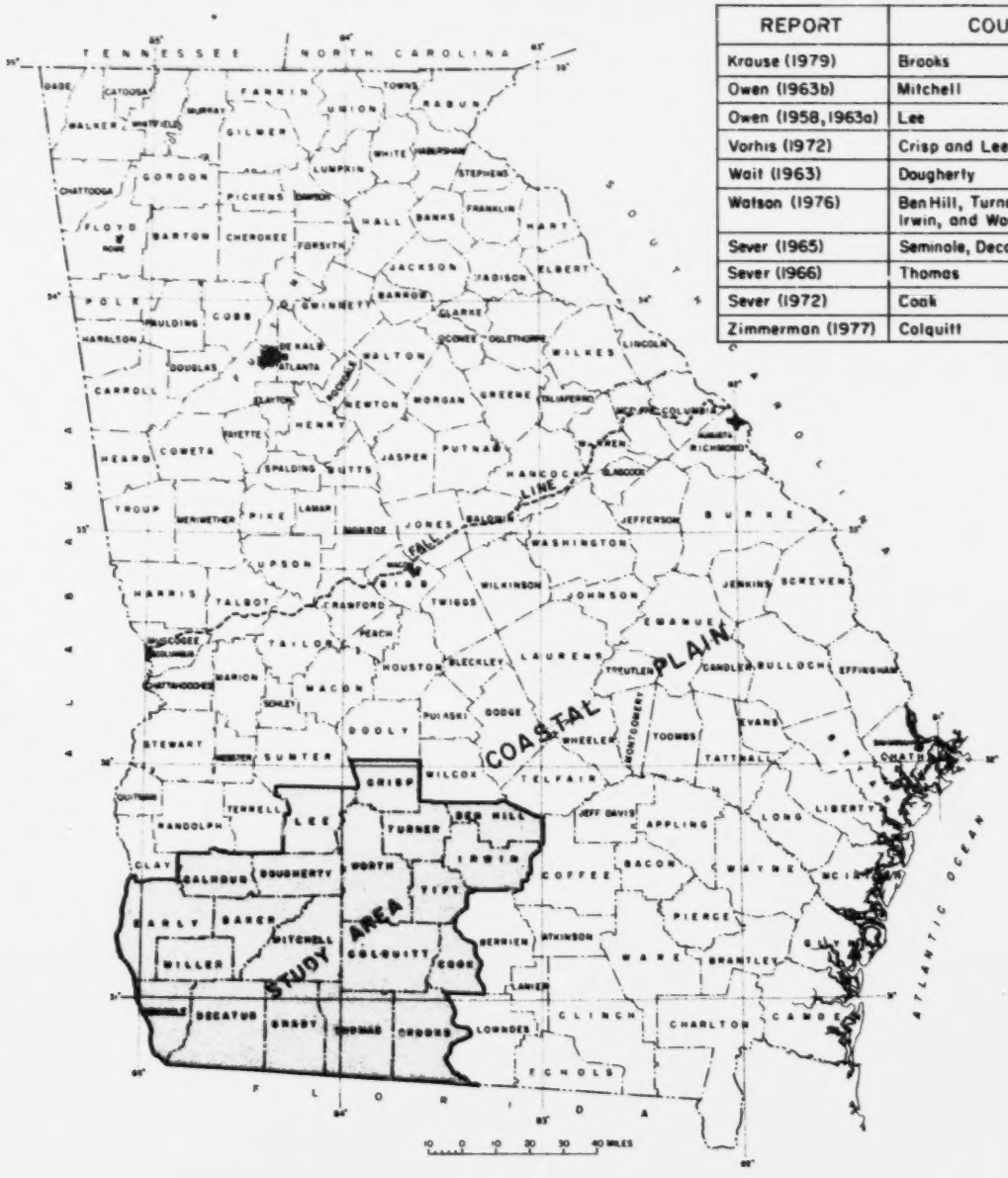

Figure 1.—Location of study area and counties described in previous hydrologic reports.

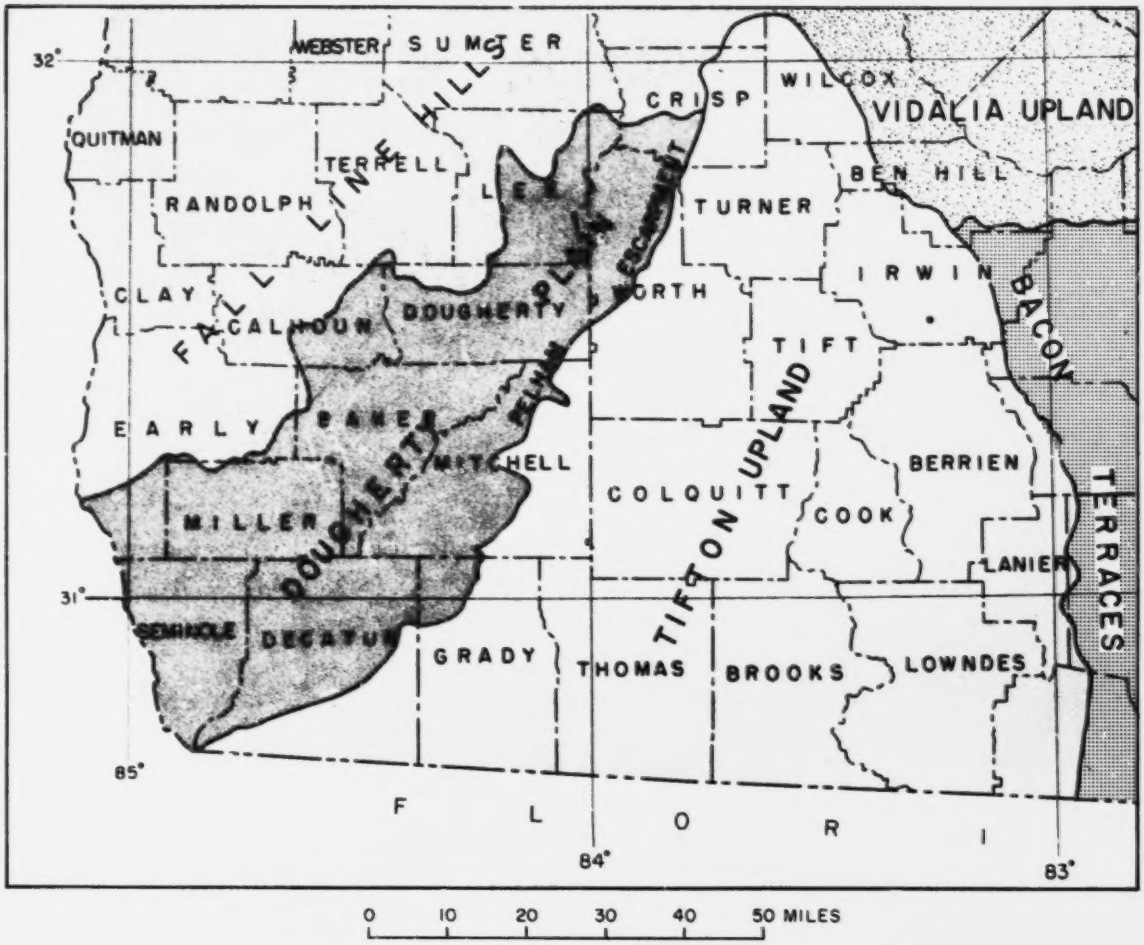

Figure 2.—Physiographic districts in study area.

PREVIOUS STUDIES

There have been no previous studies relating ground-water use, quality, and availability to agriculture in the study area. However, there have been studies on the ground-water resources of several counties within the study area.

The first comprehensive reports about ground water in the Georgia Coastal Plain, including the study area, are by McCallie (1898 and 1908). Reports are available on the ground-water resources in Brooks County (Krause, 1979); Lee County (Owen, 1958 and 1963a); Mitchell County (Owen, 1963b); Seminole, Decatur, and Grady Counties (Sever, 1965); Thomas County (Sever, 1966); Cook County (Sever, 1972); Lee and Crisp Counties (Vorhis,

1972); Dougherty County (Wait, 1963); Worth, Turner, Ben Hill, Tift, and Irwin Counties (Watson, 1976); and Colquitt County (Zimmerman, 1977). The location of these counties is shown in figure 1.

GEOHYDROLOGIC BACKGROUND

Geology

The Coastal Plain province, of which southwest Georgia is a part, extends from the Fall Line at its northernmost edge toward the southeast (fig. 1 and plate 1). Sedimentary rocks, dipping gently to the southeast, underlie the Coastal Plain (fig. 3). The oldest exposed sediments of Late Cretaceous to early Tertiary age are composed of sand, clay, and gravel and

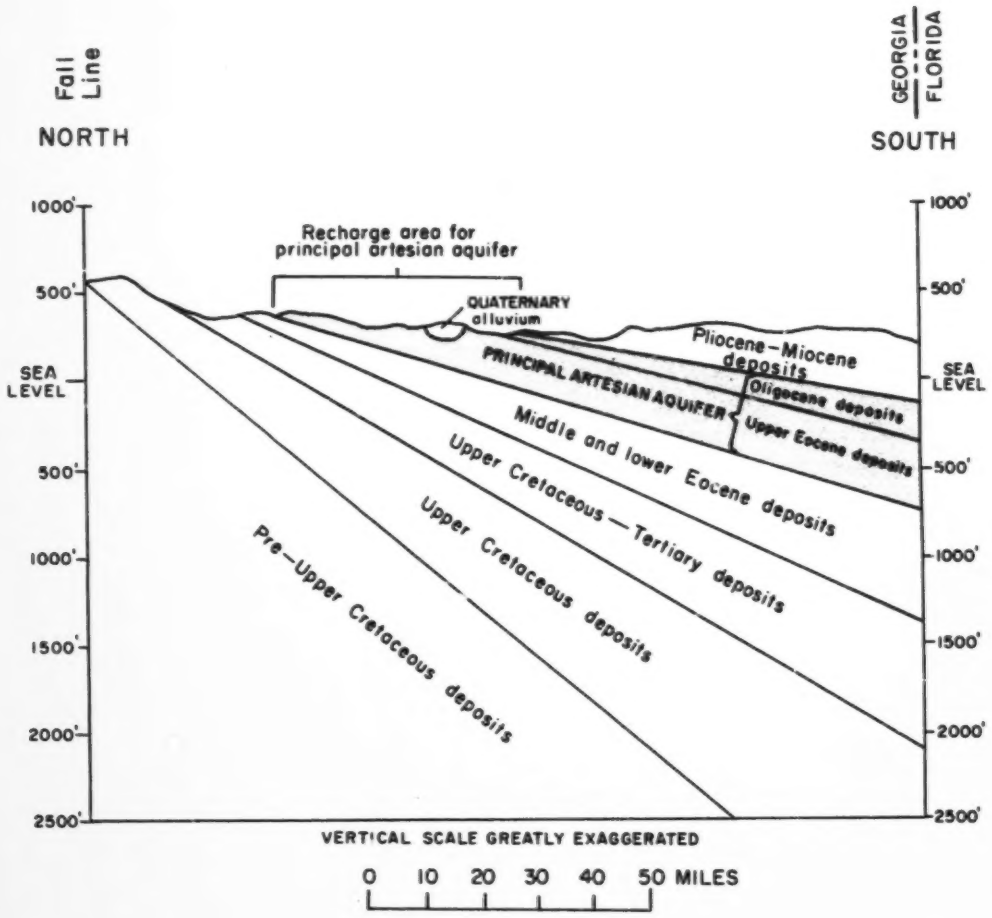

Figure 3.—Relation of the principal artesian aquifer to overlying and underlying deposits.

occur in a band just south of the Fall Line. These sediments are overlain by sand and limestone of Paleocene, early Eocene and middle Eocene ages. The next younger deposits are carbonate rocks, primarily limestone, of late Eocene and Oligocene age. These upper Eocene and Oligocene limestones form the part of the principal artesian aquifer that contributes most ground water to the irrigation systems in the study area. Younger deposits of Miocene, Pliocene, and Quaternary age cropping out at the surface of the upper Eocene and Oligocene deposits may contribute water locally, but in southwest Georgia the quantity is small compared to that obtained from the principal artesian aquifer.

Hydrology

The principal artesian aquifer, the source of most ground water used for irrigation in southwest Georgia, is recharged primarily by precipitation in the area where the aquifer intersects the land surface (fig. 3) or where the aquifer is overlain by permeable sand and silt deposits. Water entering the aquifer moves down the hydraulic gradient through the permeable carbonate rocks.

The ground-water levels in the study area fluctuate in response to the amount of rainfall recharging the aquifer and in response to pumpage. Where the principal artesian aquifer is highly permeable, as it is in the Dougherty Plain, recovery from seasonal water use generally occurs in a few days or weeks.

A long-term hydrograph from observation well 6 near Albany, Dougherty County, shows the seasonal response of water levels in the principal artesian aquifer (fig. 4). Long-term water-level trends for the period of record indicate two periods (1963 and 1967-69) when water levels remained significantly below the median of record. Long-term climatic water-level declines lasting over 2 or 3 years are indicative of a hydrologic drought.

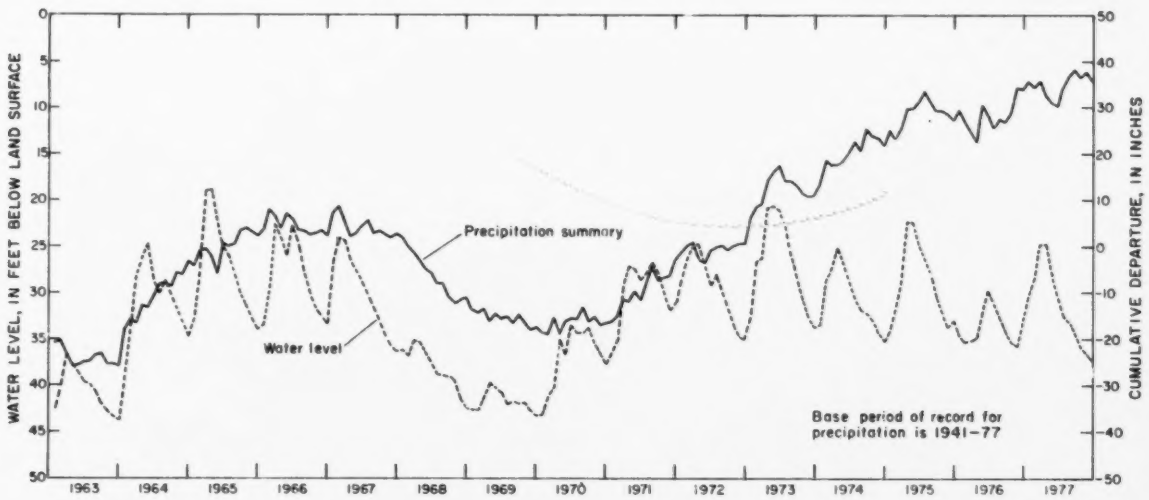

Figure 4.—Water levels in observation well 6, Albany, Dougherty County, and the cumulative departure of precipitation, 1963—77.

When the hydrograph is compared with the cumulative precipitation departure summary based on the 1940-70 base period for climatological station Albany 3 SE (National Oceanic and Atmospheric Administration, 1941-71), the periods of hydrologic drought coincide with the periods of long-term precipitation deficiency. A further comparison indicates that the general trend for the past 5 years has been a period of surplus precipitation. During this period, the water levels have shown a significant departure. This departure may be due, in part, to increased pumpage in southwest Georgia. The same pattern has been noted in other observation wells in the study area.

Figure 5 shows the maximum, minimum, and average median water level for January 1963 - May 1978 and mean water level for January 1977 - May 1978. The mean water level for 1977 was 2 ft lower in the last half of 1977 than the average median for the 16-year record, but had reached the average median by the end of January 1978.

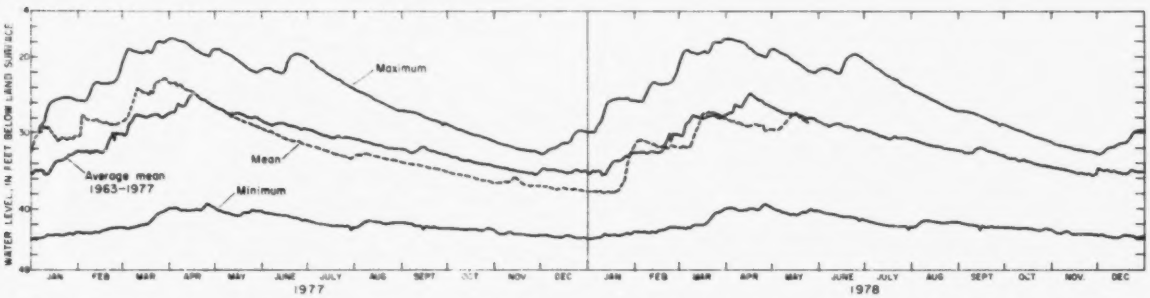
WATER LEVEL, IN FEET BELOW LAND SURFACE
Maximum
Mean
Average mean 1963-1977
Minimum
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1977
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1978

Figure 5—Long-term water-level conditions, 1963-77, compared to the mean water levels for observation well 6, Albany, Dougherty County, 1977.

A long-term hydrograph for observation well 2 in Decatur County (fig. 6) indicates the seasonal fluctuation of the water level in the well. The

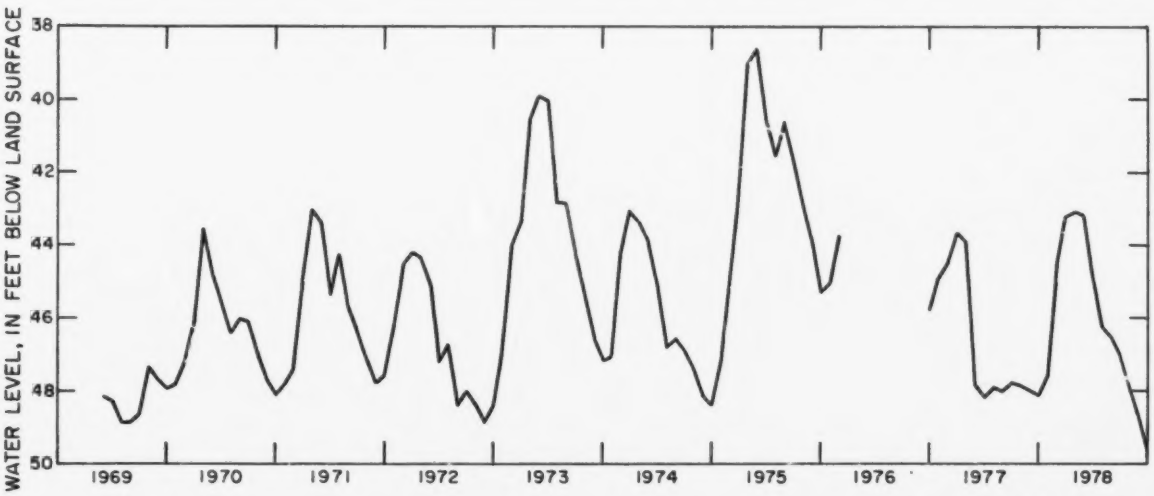

Figure 6.—Water levels in observation well 2, Decatur County, June 1969—April 1978.

January 1977 - April 1978 hydrograph for this well (fig. 7) shows the normal seasonal trend in addition to sharp declines and recoveries when a nearby irrigation system was turned on and off (Apr. through June). In March 1978, the water level recovered to the spring high of March 1977 even though seasonal demands on the principal artesian aquifer were high during the spring and summer months. Somewhat similar hydrographs were obtained from other observation wells in the Dougherty Plain.

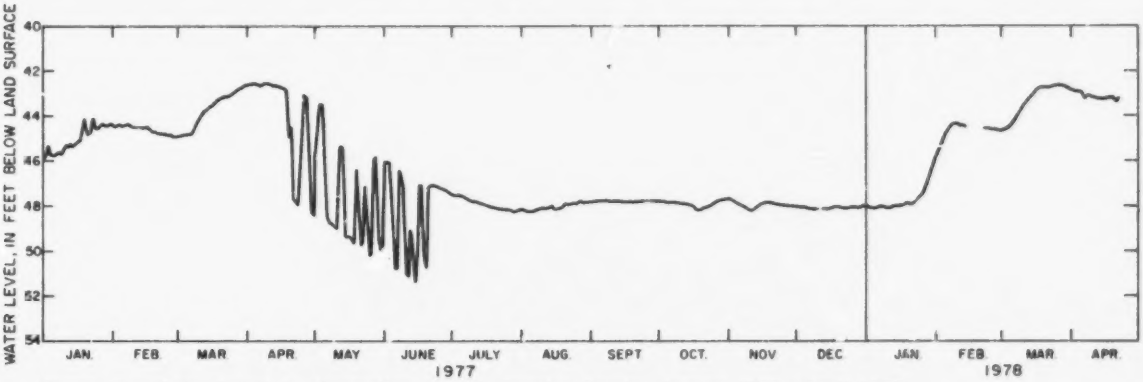

Figure 7.—Water levels in observation well 2, Decatur County, January 1977—April 1978.

Water-level measurements were made during the fall low in November-December 1977 and during the spring high of March 1978 to compare the effects of the seasonal fluctuation of water levels in response to precipitation and pumpage. These measurements were made on irrigation and observation wells in the Dougherty Plain, where more than 42 billion gallons of water was used for irrigation in 1977. A potentiometric surface for each period was constructed from these water-level measurements (plates 2 and 3).

A comparison of the potentiometric surface of November-December 1977 (fall low) with the potentiometric surface of March 1978 (spring high) shows a general difference of about 10 ft in water levels throughout the area. During the fall of 1977, water levels in the aquifer were at their yearly low after extensive agricultural pumping during the preceeding summer.

The hydrograph of observation well 3 in Miller County (fig. 8) shows that the water level declined sharply in April and May 1977 when precipitation was below normal and agricultural pumpage was high. The water level rapidly stabilized during June and remained low through early December. This stabilization probably indicates that during periods of pumping, as the water levels were drawn down to the base level of Spring Creek, which is near the well, water from the creek locally recharged the principal artesian aquifer.

In January 1978 the water level in observation well 3 recovered rapidly in response to the winter rains. By March 1978 the level had reached the spring high. The regional recovery of water levels is also reflected on the potentiometric map for March 1978.

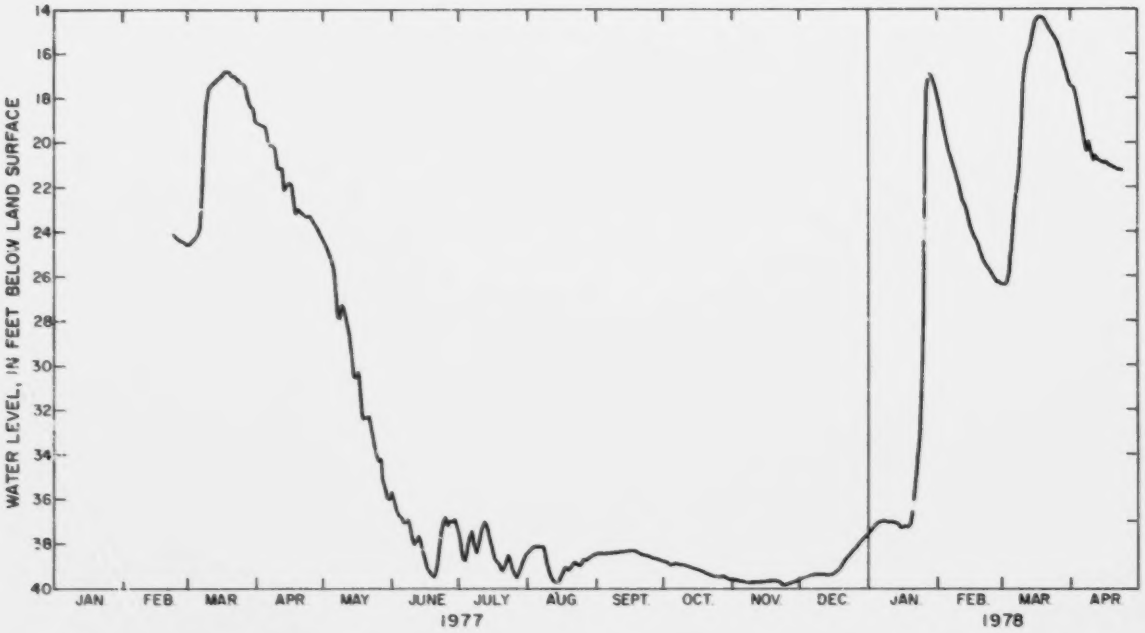

Figure 8.—Seasonal response of water levels to pumping in observation well 3, Miller County, February 1977—April 1978.

The rapid decline of water levels in the Dougherty Plain during 1977 reflects the sensitivity of the system to precipitation and pumpage. Expansion of the ground-water level network could provide some of the data needed to develop predictive models pertaining to ground-water availability. These models could evaluate the response of the principal artesian aquifer to the increased withdrawal of large quantities of water for supplemental irrigation during periods of extended agricultural and hydrologic drought.

In the Dougherty Plain, irrigation wells producing water from the principal artesian aquifer are, on the average, cased to 60 ft and are open to a total depth of 250 ft. Yields of as much as 1,500 gal/min have been reported from these wells. Irrigation wells in the Tifton Upland produce as much as 1,200 gal/min from the principal artesian aquifer. Well depths are generally greater than those in the Dougherty Plain. The total depths are usually between 500 and 600 ft except in eastern Lee, Grady, and Thomas Counties, where well depths are less than 300 ft below land surface.

Only a small percentage of the total ground water withdrawn for irrigation is used outside the Dougherty Plain. Irrigation wells in the Fall Line Hills district yield water primarily from the Paleocene deposits and secondarily from the lower Eocene deposits. The wells have an average casing depth of 400 ft and an average total depth of 860 ft. Reported yields are as much as 1,200 gal/min, but most yields are less than 800 gal/min. Wells in the southeastern corner of the Vidalia Upland district yield as much as 1,200 gal/min from the principal artesian aquifer. The

average casing depth is 200 ft and the average total depth is 700 ft. A small percentage of the irrigation water may also come from limestone in the shallower Miocene deposits. Wells in Ben Hill County, Bacon Terraces district, yield an average of 100 gal/min from sand and limestone in the Miocene deposits. Wells are open to this aquifer from 160 to 400 ft below land surface.

GROUND-WATER USE

Three types of irrigation systems are commonly used in southwest Georgia: center-pivot, cable-tow, and pipe systems. The type of system used depends on the flatness and size of the field, the availability of water, the crop to be irrigated, and the cost of buying and maintaining the system.

Center-pivot systems have a mainline pipe, supported by towers of various designs, pivoting around a central point. Each tower is independently motor driven. Sprinklers are located along the mainline pipe and some systems have a corner unit to irrigate fields of other than circular shape. The reported capacities of center pivots range from 550 gal/min for systems irrigating less than 100 acres to 1,500 gal/min for larger systems.

The system most commonly used for irrigating smaller acreages, especially on irregularly shaped fields, is the cable tow. The unit, topped by a single volume gun, is towed across the field to a fixed point by a self-winding cable. Reported capacities range from 300 to 600 gal/min.

Permanent solid-set and portable-pipe systems are not as significant as pivots and cable tows in total acreage irrigated and in the quantity of water used in the study area. Trickle irrigation systems, with nozzles allowing the water to trickle from the mainline pipe onto the ground, have recently become popular with pecan growers. The capacities of these pipe systems are variable because the capacity of each system depends on the length of pipe, the nozzle type, and the nozzle spacing.

The total number of acres irrigated from all sources in the study area increased from approximately 130,000 in 1976 to 261,000 in 1977 (table 1). Acreage irrigated entirely by ground water increased 85 percent for the same period. By February 1978 the acres planned for irrigation increased to 376,000, and many new irrigation systems were being installed. Summaries for each county are given in table 2.

The greatest growth in ground-water use and in irrigated acreage has been in the Dougherty Plain district. Plate 4 shows the concentration of irrigation wells in the Dougherty Plain in 1977, and figure 9 gives the percentage of total irrigation water that was supplied by wells, ponds, and streams.

During the 1977 growing season, about 92 percent of all ground water used for irrigation in the study area came from the principal artesian aquifer. Most of the irrigated acreage in the Dougherty Plain is in Baker,

Table 1.—Summary of irrigation data in the 20-county study area in southwest Georgia

		Water Source											
		1976				1977				Jan. 1978			
		Well	Well-Pond	Pond	Stream	Well	Well-Pond	Pond	Stream	Well	Well-Pond	Pond	Stream
Type of irrigation system	Center pivot	367	10	11	17	716	21	26	36	812	22	35	61
	Cable tow	158	158	148	40	414	365	420	102	429	379	436	104
	Solid set	13	3	27	0	20	5	80	0	27	5	82	0
	Portable pipe	7	27	131	1	7	53	319	4	6	55	326	4
Acres irrigated		85,100	17,600	18,800	8,400	150,000	40,100	53,800	16,800	—	—	—	—
Total acres irrigated		130,000				261,000				—			
Water applied (Mgal)		13,000	2,300	3,100	1,100	43,500	8,100	10,200	3,100	—	—	—	—
Total water applied (Mgal)		19,500				64,900				—			

Table 2.--Summary of irrigation inventory by county
[Type of irrigation system: P, pivot; CT, cable tow; SS, solid set; PP, portable pipe]

County	Date	Well				Acreage irrigated	Water used, million gallons	Well pond				Acreage irrigated	Water used, million gallons	Pond				Acreage irrigated	Water used, million gallons	Stream				Acreage irrigated	Water used, million gallons	Total acreage irrigated	Total water used, million gallons
		P	CT	SS	PP			P	CT	SS	PP			P	CT	SS	PP			P	CT	SS	PP				
Baker	1976	62	26	0	0	14,000	1,870	0	23	0	0	1,440	245	0	13	0	0	690	115	2	10	0	0	1,080	110	17,210	2,340
	1977	83	38	0	0	16,700	5,200	0	32	0	0	2,400	840	0	34	0	0	1,340	540	2	21	0	0	3,150	400	23,590	6,980
	Jan. 1978	103	38	0	0			0	36	0	0			0	34	0	0			14	23	0	0				
Ben Hill	1976	0	0	0	0			0	0	0	0			0	0	1	0	10	0.4	0	0	0	0			10	0.4
	1977	0	16	0	0	800	95	0	4	0	0	150	10	0	49	0	27	1,860	150	0	0	0	0			2,810	255
	Jan. 1978	0	16	0	0			0	4	0	0			0	49	0	27			0	0	0	0				
Brooks	1976	0	1	0	0	110	30	0	4	0	5	550	70	0	0	0	15	570	110	0	0	0	0			1,230	210
	1977	0	1	0	0	110	30	0	10	0	8	1,660	250	0	7	0	27	1,500	250	0	0	0	0			3,270	530
	Jan. 1978	0	1	0	0			0	10	0	8			0	7	0	27			0	0	0	0				
Calhoun	1976	9	0	0	0	950	70	1	2	0	0	800	50	3	3	0	0	985	270	7	1	0	0	2,040	215	4,770	610
	1977	14	2	0	0	1,530	220	3	3	0	0	1,200	120	8	7	2	0	2,790	270	14	9	0	0	4,240	670	9,760	1,280
	Jan. 1978	15	2	0	0			3	3	0	0			8	7	2	0			14	9	0	0				
Colquitt	1976	0	0	0	0			2	8	1	3	1,600	100	0	11	0	21	1,250	85	0	0	0	0			2,850	1.85
	1977	0	0	0	0			5	8	2	3	3,600	310	0	11	0	39	4,730	410	0	0	0	0			8,330	720
	Jan. 1978	2	1	0	0			6	10	2	5			0	27	1	46			0	0	0	0				
Cook	1976	0	0	0	0			0	0	0	0			0	0	0	1	30	5	0	0	0	0			30	5
	1977	0	2	1	0	115	70	0	2	0	19	1,220	270	0	7	46	22	3,410	740	0	0	0	2	35	10	4,780	1,090
	Jan. 1978	0	2	1	0			0	2	0	19			0	7	46	22			0	0	0	2				
Crisp	1976	4	1	0	0	620	100	0	6	0	0	650	75	2	8	0	0	1,160	190	4	9	0	0	1,230	355	3,660	720
	1977	5	2	0	0	775	275	0	13	0	0	1,250	175	3	31	0	0	2,920	500	4	9	0	0	1,355	600	6,300	1,550
	Jan. 1978	12	3	0	0			0	13	0	0			3	31	0	0			4	9	0	0				
Decatur	1976	113	31	2	0	24,400	4,430	0	0	1	0	20	10	1	3	1	0	380	50	0	2	0	0	140	20	24,940	4,510
	1977	267	87	2	0	34,800	10,400	0	6	1	0	450	130	1	8	4	0	900	240	0	4	0	0	270	80	36,420	10,850
	Jan. 1978	288	87	2	0			0	7	1	0			5	8	4	0			0	4	0	0				
Dougherty	1976	4	2	7	1	1,320	300	0	0	0	0			0	0	0	0			0	0	0	0			1,320	300
	1977	10	3	7	1	3,160	575	0	0	0	0			0	2	0	0	80	5	0	0	0	0			3,240	580
	Jan. 1978	10	3	7	1			0	0	0	0			0	2	0	0			0	0	0	0				
Early	1976	14	11	0	0	5,000	415	4	23	0	0	3,000	340	1	2	0	0	160	60	4	13	0	0	1,740	195	9,900	1,010
	1977	22	25	1	0	8,200	1,510	4	42	0	0	4,020	990	2	4	0	0	480	130	7	32	0	0	3,800	720	16,500	3,350
	Jan. 1978	22	25	1	0			4	42	0	0			2	4	0	0			7	32	0	0				

Table 2.—Summary of irrigation inventory by county—Continued
[Type of irrigation system: P, pivot; CT, cable tow; SS, solid set; PP, portable pipe]

County	Date	Well				Acreage irrigated	Water used, million gallons	Well pond				Acreage irrigated	Water used, million gallons	Pond				Acreage irrigated	Water used, million gallons	Stream				Acreage irrigated	Water used, million gallons	Total acreage irrigated	Total water used, million gallons
		P	CT	SS	PP			P	CT	SS	PP			P	CT	SS	PP			P	CT	SS	PP				
Grady	1976	0	1	1	0	215	45	2	1	0	0	325	35	1	9	21	12	1,580	570	0	0	0	0			2,120	650
	1977	3	1	1	0	600	175	2	4	0	0	520	135	1	24	22	21	4,430	1,310	0	2	0	0	380	100	5,930	1,720
	Jan. 1978	3	1	1	0			2	4	0	0			1	24	22	21			0	2	0	0				
Irwin	1976	0	1	0	0	150	10	0	3	0	3	325	35	0	32	0	35	2,265	100	0	2	0	1	60	5	2,800	150
	1977	0	11	0	0	2,270	80	0	13	0	6	1,170	70	0	110	0	105	9,320	420	0	4	0	1	130	10	12,880	580
	Jan. 1978	0	11	0	0			0	13	0	6			0	110	0	105			0	4	0	1				
Lee[1]	1976	-	-	-	-	1,500	300	-	-	-	-	500	40	-	-	-	-	200	40	-	-	-	-	1,800	130	4,000	510
	1977	15	1	4	0	3,450	730	5	15	0	0	1,680	290	2	5	0	0	660	110	8	10	0	1	2,350	290	8,340	1,420
	Jan. 1978	15	1	8	0			5	15	0	0			2	5	0	0			11	10	0	1				
Miller	1976	37	45	0	0	12,200	1,500	1	12	0	0	1,150	125	0	0	0	0			0	2	0	0	260	25	13,610	1,650
	1977	76	158	0	0	32,200	8,060	1	92	0	0	7,300	1,590	0	1	0	0	70	15	0	9	0	0	640	155	40,210	9,820
	Jan. 1978	81	162	0	0			1	92	0	0			0	1	0	0			0	9	0	0				
Mitchell	1976	44	13	2	5	10,200	2,160	0	0	0	0			0	1	0	0	20	10	0	0	0	0			10,220	2,170
	1977	103	25	3	5	23,000	8,760	0	1	0	0	130	65	3	3	0	0	370	125	0	0	0	0			23,500	8,950
	Jan. 1978	125	28	6	4			0	1	0	0			6	3	0	0			0	0	0	0				
Seminole	1976	76	23	1	0	13,500	1,600	0	56	0	0	4,000	365	0	2	0	0	100	15	0	0	0	0			17,600	1,980
	1977	102	34	1	0	18,900	5,840	0	92	0	0	7,630	1,480	0	8	0	0	600	55	0	1	0	0	60	15	27,190	7,390
	Jan. 1978	117	40	1	0			0	99	0	0			0	8	0	0			0	1	0	0				
Thomas	1976	0	2	0	0	250	70	0	2	0	0	280	55	0	1	0	2	190	5	0	0	0	0			720	130
	1977	2	3	0	0	300	155	1	5	0	0	1,100	145	0	8	0	9	820	65	1	0	0	0	50	10	2,470	375
	Jan. 1978	2	3	0	0			1	5	0	0			0	8	0	9			1	0	0	0				
Tift	1976	1	0	0	1	190	50	0	6	0	9	1,170	450	1	20	2	25	3,830	600	0	0	0	0			5,190	1,100
	1977	1	0	0	1	190	65	0	7	0	10	2,410	545	1	21	3	26	5,160	890	0	0	0	0			7,760	1,500
	Jan. 1978	2	0	0	1			0	7	0	10			2	21	4	26			0	0	0	0				
Turner	1976	1	1	0	0	285	45	0	8	0	7	1,150	260	0	26	0	20	3,330	370	0	0	0	0			4,760	680
	1977	5	4	0	0	1,230	185	0	11	0	7	2,180	595	1	50	0	42	7,790	1,320	0	0	0	0			11,200	2,100
	Jan. 1978	5	4	0	0			0	11	0	7			1	50	0	42			0	0	0	0				
Worth	1976	2	0	0	0	260	40	0	4	1	0	690	50	2	17	2	0	2,040	470	0	1	0	0	70	10	2,990	570
	1977	8	1	0	0	1,000	195	0	5	2	0	1,040	95	4	30	3	1	4,600	2,660	0	1	0	0	100	10	6,740	2,960
	Jan. 1978	10	1	0	0			0	5	2	0			5	30	3	1			0	1	0	0				

[1]/1976 estimated - Lee County added to study in 1977.

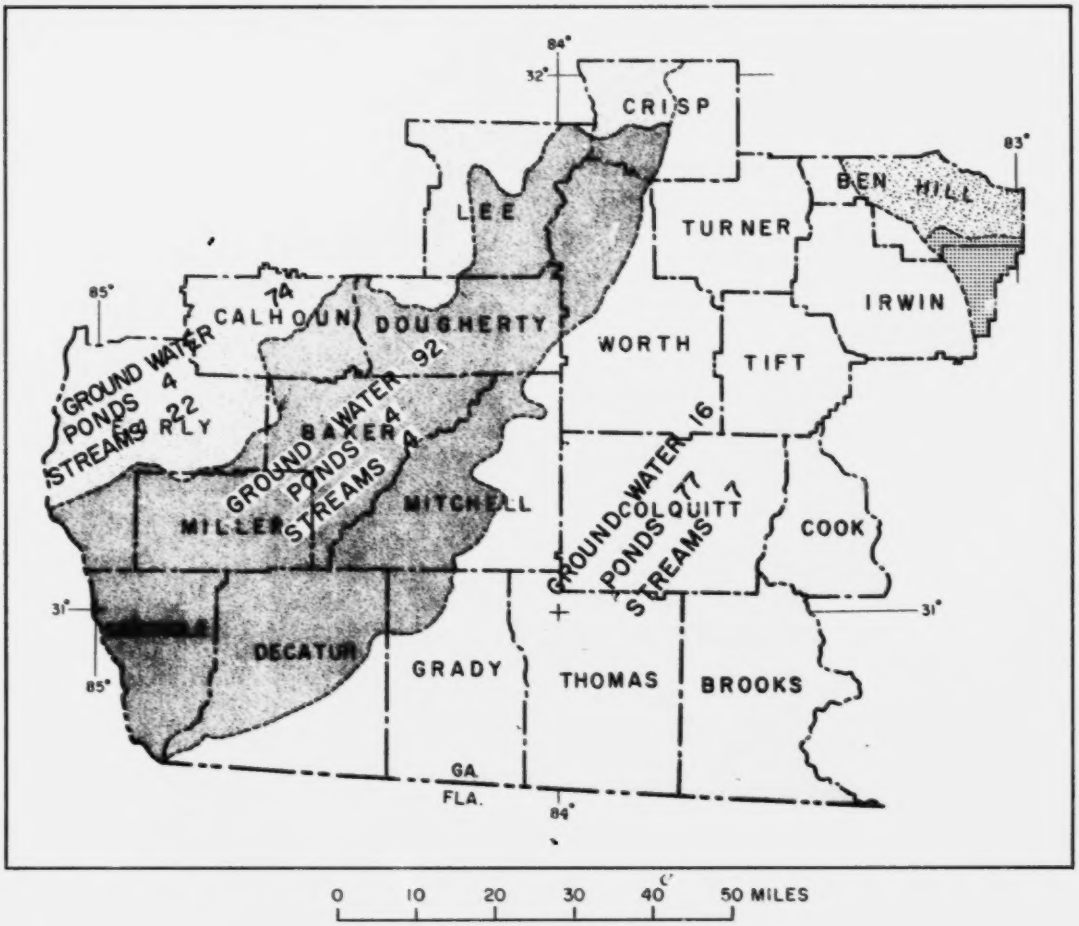

Figure 9.—Percentage distribution of irrigation water use by source, 1977.

Decatur, Miller, Mitchell, and Seminole Counties. The quantity of ground water used for irrigation in these counties during the 1977 growing season was more than 42 billion gallons. Average daily pumpage during the 3 months of heaviest irrigation (June-Aug.) was more than 450 Mgal/d. If all the reported systems in the five-county area had been operating at the same time, irrigation pumpage could have reached the rate of 1.8 billion gallons per day.

Figure 10 shows a comparison of the pumpage by irrigators in the five-county area of the Dougherty Plain, adjusted to a 365-day period, with the average daily pumpage of ground water by industries and municipalities throughout the State. The irrigation pumpage of 116 Mgal/d, even when averaged over 365 days, is a higher daily rate of ground-water withdrawal than that of the major industrial and municipal ground-water users in Georgia.

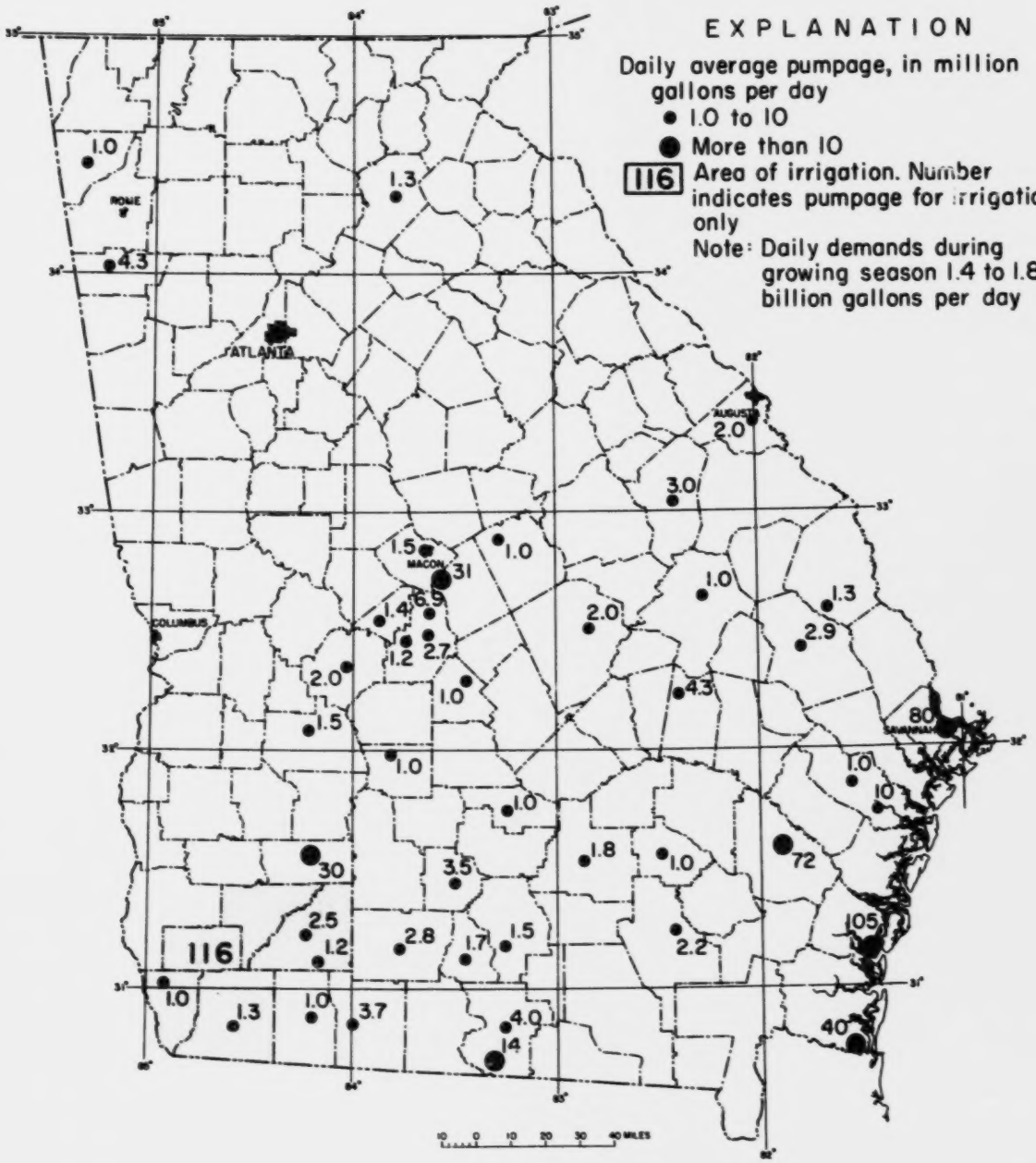

Figure 10.—Estimated ground-water use, 1977.

The inventory of the five-county area in the Dougherty Plain indicated that water use increased from about 12 billion gallons for 81,000 acres in 1976 to more than 42 billion gallons for more than 143,000 acres in 1977. By February 1978 preparations were being made to irrigate more than 214,000 acres during the 1978 growing season and this is expected to increase. The quantity of ground water to be used to irrigate this acreage will depend upon the amount of precipitation deficiency, but could be as much as 75 billion gallons for the five-county area if there is an agricultural drought similar to the one in 1977.

Figure 11 shows the theoretical water-level decline after 5 days of pumping irrigation wells in Decatur County. The wells plotted on the map are wells supplying water to 133 center-pivot irrigation systems, each system having a reported capacity of 1,200 to 1,500 gal/min. A theoretical transmissivity of 80,000 feet squared per day and a theoretical storage coefficient of 0.003, both calculated for a carbonate aquifer in another part of the Coastal Plain, were used to determine the areal distribution of the water-level decline. The water-level decline would extend to distances of 3 or 4 miles from pumpage centers northwest of the Flint River if irrigation were continuous over a 5-day period. The areal extent of the decline is predicted to be even greater in the future because of the increased number of center-pivot irrigation systems (288 total) installed by February 1978. This number of systems will probably be close to 350 for Decatur County by the growing season of 1978.

Less ground water is used in the Tifton Upland district. The important water sources in this district are ponds and streams (fig. 9). However, if extended dry periods and subsequent water demands for irrigation cause the ponds to dry up, there will probably be increased usage of ground water from the principal artesian aquifer.

GROUND-WATER QUALITY

Water samples were collected from 19 wells in the study area (plate 4). Fifteen of these samples were collected from wells penetrating the principal artesian aquifer, one was collected from a well tapping the Upper Cretaceous-Tertiary deposits, and the remaining three samples were collected from shallow wells in alluvium in the Tifton Upland.

Analyses were made for standard inorganic and organic constituents and for selected trace metals. The samples were analyzed for trace metals such as arsenic, mercury, and copper because these metals were major components in pesticides and herbicides used especially in the 1920's (table 3). The concentrations of trace metals were below the recommended limits for drinking water (Georgia Department of Natural Resources, 1977) except in well 1 tapping the Upper Cretaceous-Tertiary deposits. Water from that well had high concentrations of suspended copper and lead resulting from a disintegrating bushing in the well pump.

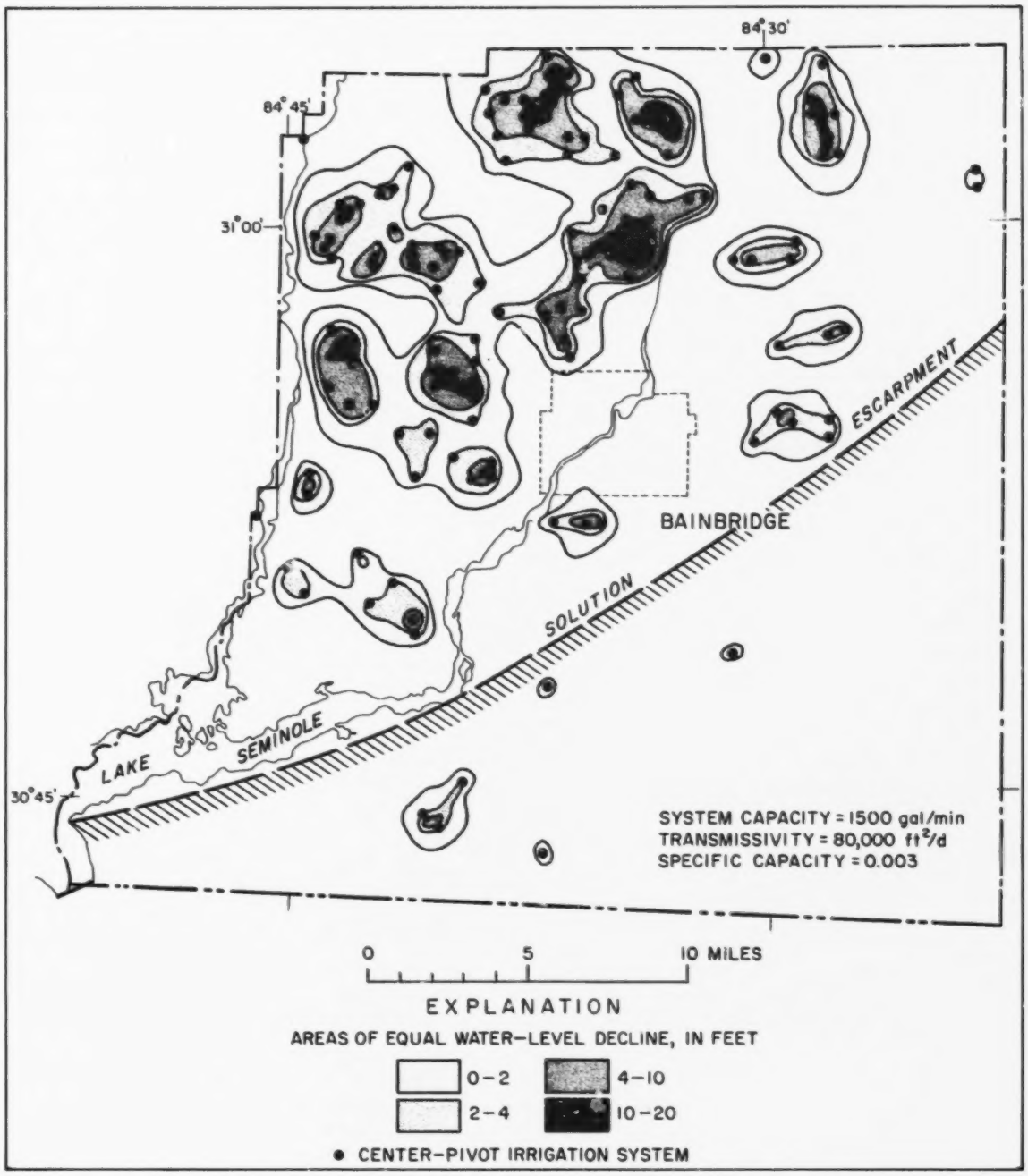

Figure 11.—Areal distribution of a theoretical water-level decline after 5 days of pumping 133 irrigation wells in Decatur County.

Table 3.—Concentration of selected constituents from ground water
[Results in micrograms per liter except as indicated. T, trace; <10, less than 10.
Physiographic districts: FLH, Fall Line Hills; DP, Dougherty Plain; TU, Tifton Upland]

Well number	Physiographic district	CONSTITUENT																		Total nitrite plus nitrate (N) (mg/L)	Depth to top of sample interval (ft)	Depth to bottom of sample interval (ft)
		TOTAL ORGANIC											TOTAL TRACE METAL									
		Aldrin	Lindane	Chlordane	DDD	DDE	DDT	Dieldrin	Endrin	Toxaphene	Heptachlor	Heptachlor epoxide	Mirex	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Zinc			
1	FLH	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0	40	130	82	0.5	80	0.06	650	804
2	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	0	0	10	10	0	T	20	3.0	75	234
3	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	0	0	<10	17	0	T	10	.92	180	210
4	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	1	0	<10	4	0	T	10	.30	100	130
5	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	0	0	<10	8	0	T	10	7.8	85	145
6	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	0	0	20	22	0	T	20	.41	90	170
7	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	1	0	<10	54	12	T	40	2.2	100	186
8	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	1	0	30	14	2	T	20	.40	95	200
9	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	0	0	<10	7	0	T	20	.63	147	485
10	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	0	0	<10	3	0	T	10	.09	594	776
11	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	1	0	10	2	0	T	30	.69	108	116
12	TU	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	0	0	<10	2	0	T	10	.01	250	432
13	DP	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	0	0	<10	4	0	0.5	0	.44	150	335
14	TU	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	1	0	<10	0	0	T	0	.02	190	720
15	FLH	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	1	0	<10	5	0	T	60	.81	124	264
16	TU	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	1	0	20	31	5	T	330	.00	6.0	6.0
17	TU	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	0	1	10	6	3	T	30	.04	12	12
18	TU	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	1	0	20	10	3	T	20	.02	93	98
19	TU	.00	.00	.0	.00	.00	.00	.00	.00	0	.00	.00	.00	0	0	10	11	7	T	50	.06	8.0	8.0

Samples were analyzed for selected organic compounds representative of agricultural chemicals used to control pests and weeds. The analytical results (table 3) show no detectable amounts of the organic compounds in the water from the 19 wells.

The presence of high nitrate concentrations in ground water can be indicative of contamination by fertilizer. Nitrogen in fertilizer is changed to highly soluble nitrate in the soil zone. Table 3 shows the concentration of total nitrite plus nitrate as N (nitrogen) in well water from the study area. Concentrations of nitrite plus nitrate as N of 0.3 to 7.8 mg/L in the Dougherty Plain district in wells cased to depths of 75 to 100 ft below land surface could be the result of contamination by fertilizer. The highest value of 7.8 mg/L is from well 5 located in an irrigated field in Miller County.

Jackson and others (1973) conducted a study from 1969-71 to determine the effect of nitrogen applications on surface and subsurface runoff. In the Tift County area the subsurface runoff is controlled by a semipermeable clay layer covered by 2 to 5 ft of permeable sandy loam. The study showed that dissolved nitrate percolates through the surface material and concentrates in the subsurface runoff. Therefore, where the aquifer is recharged from the surface, nitrate contamination may be possible.

Information was obtained from L. E. Asmussen, U.S. Department of Agriculture, on research concerned with the effect of organic chemicals on surface and subsurface runoff (oral commun., 1978). Asmussen and others (1977) conducted studies on test plots in Tift County. The amounts of chemicals applied (nutrients, pesticides, herbicides, and nematicides) were known and the surface and subsurface runoff were monitored. The results showed that the subsurface concentrations of two herbicides and one nematicide were insignificant, even though in one study the quantity of subsurface runoff was greater than the surface runoff. Some organic compounds were found to degrade in a relatively short period of time. One compound was more persistent, requiring over 100 days before it was no longer detectable in the soil zone.

The studies conducted by Asmussen and others were in the Tifton Upland district, where a semipermeable clay confining layer retards recharge to the water-table aquifer. In the Dougherty Plain, however, this extensive clay layer is absent and rainfall recharges the principal artesian aquifer through the overlying sandy loam. Infiltrating water could carry agricultural chemicals, such as nitrate, into the ground-water reservoir.

Water-quality analyses indicate that in the principal artesian aquifer no chemical constituents have concentrations above the recommended limits for drinking water that resulted from agricultural practices in the study area. However, because toxic chemicals could reach the aquifer, continued monitoring of water quality from an expanded network of shallow wells in alluvium and deeper wells in the principal artesian aquifer could forewarn of potential problems.

The new and expanding practice of dispersing chemicals through irrigation systems also poses the potential problem of the accidental backflushing of toxic materials into the aquifer. The installation and maintenance of check valves on all systems could prevent this from happening.

SUMMARY AND CONCLUSIONS

Limestone aquifers contribute most of the water used for irrigation in southwest Georgia. The principal artesian aquifer, composed mainly of limestone, is highly permeable and allows relatively rapid movement of water through the aquifer. The large yearly decline and recovery (10 to 20 ft) of water levels in the Dougherty Plain district reflect a rapid response to precipitation and pumpage. Because of the ease with which ground water can be obtained throughout the Dougherty Plain and the suitability of the land to center-pivot irrigation systems, this district represents an area of high and increasing ground-water use. In a five-county area in the Dougherty Plain, the number of acres being irrigated increased from 81,000 in 1976 to 143,000 in 1977, and the water use increased from 12 to about 42 billion gallons during the same period.

In most parts of the study area the dry spring and summer months of 1977 did not have a long-lasting effect on the water levels in the principal artesian aquifer. However, a comparison of the long-term water levels with the corresponding cumulative precipitation departure summary for Dougherty County shows a general trend of overall water-level departure from precipitation trends over a several-year period. This may reflect the impact of long-term pumping on the aquifer. The impact of increased irrigation on water levels in the aquifer, especially if hydrologic droughts like those in 1962-63 and 1968 occur, could be evaluated through the development of predictive computer hydrologic models.

Analyses of water samples from 19 wells showed no concentrations of trace metals that would indicate contamination of the ground-water source by pesticides used in historical agricultural practices. There were no detectable concentrations of selected organic compounds indicative of agricultural chemicals being applied today.

The concentrations of nitrite plus nitrate as N in three wells in the Dougherty Plain district may indicate that some agricultural practices need to be monitored more closely in areas where the connection to the underlying limestone aquifer is direct. Periodic sampling from a statewide water-quality network could detect the presence of toxic chemicals in the major aquifers before they create a health hazard.

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